UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

IEK 309E – Chemodynamics
[Kimodinamik]

Duration: 3 hours
Masa: 3 jam

Please check that this examination paper consists of SEVEN (7) pages of printed material before you begin the examination.

Answer **FIVE (5)** questions. All questions can be answered either in Bahasa Malaysia or English.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH (7) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

*[Jawab **LIMA (5)** soalan. Semua soalan boleh dijawab sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

1. (a) Discuss the Conservative substances and the nonconservative substances on the water quality downstream of a point source.

(50 marks)

(b) Discuss the stagnant-film model, and the penetration theory.

(50 marks)

2. A large hole (> 10 cm) in a carrier causes a high density immiscible liquid to spill into a deep slow moving water body. With the help of a hypothetical spill situation describe and explain the forced convection dissolution phenomenon.

(100 marks)

3. Propanol in the water is being oxidized by a microbial enzyme reaction according to $C_3H_7OH + 4.5O_2 = 3CO_2 + 4H_2O$. The oxygen comes from the air above the water surface. The oxidation of propanol occurs at a constant rate. The rate of diappearance of propanol is $(-r_A) = 3.28 \times 10^{-4}$ mg/L.s. Calculate

(a) the reaction rate of oxygen consumption (kmol/s) within a m^3 of water located at the surface;

(b) the molar flux rate of CO_2 (kmol/m^2.s) as it desorbs through a m^2 of the water surface.

The atomic weights of the elements involved are: C = 12, H = 1.008, O = 16

(100 marks)

4. Describe how mass transfer coefficients in the oceanic environment can be measured with the help of a gas exchange simulation apparatus in the laboratory. Highlight the variables involved and discuss some graphical results on the liquid phase coefficient.

(100 marks)

5. The time required for a stream to recover from a hypothetical state of no dissolved oxygen to some final degree of saturation gives an indication of speed of reaeration.

(a) Calculate the time required for a stream void of oxygen to reach a 50% saturation. This is the oxygen absorption half-life, $\Delta_{O2} = \Delta^{\circ}_{O2}/2$, for this particular stream. Find the distance downstream and oxygen concentration;

(b) Calculate the time required to reach 90% saturation. Find the distance and the concentration.
Stream data: Average velocity $v_w = 0.22$ m/s; average depth $h = 1.9$ m, $D_{(O2)W} = 1.80 \times 10^{-5}$ cm^2/s at 20 °C, temperature of water = 30 °C. The temperature coefficient for the system in the temperature range is $\theta = 1.018$.

$$\rho_{(O2)W} = \rho^*_{(O2)W} - [\rho^*_{(O2)W} - \rho^{\circ}_{(O2)W}]\exp[-k_{(O2)W}t/h]$$
$$L = tv_w$$

At 30 °C, $\rho^*_{(O2)W} = 7.53$ mg O_2/L
$k_{(O2)W}/h = [D_{(O2)W}v_w]^{1/2}/h^{3/2}$
$\Delta_{O2} = \rho^*_{(O2)W} - \rho_{(O2)W}$
$k_{T1} = k_{T2}\theta^{(T1-T2)}$

(100 marks)

6. (a) Estimate the half-life of n-hexane in an oil slick of temperature 75 °F. The vapour pressure of n-hexane is 3.0 psia.

$\text{Log } p_1^* = 1.25 \log K + 1.60$ $\quad p_1^*$ in atm, $\quad 1$ atm $= 14.7$ lb$_f$/in^2
$x_{1O} = x^{\circ}_{1O}e^{-Kt}$

(50 marks)

(b) For a clean, straight natural stream as shown, estimate the volumetric flow rate and the approximate distance to complete mixing for the side bank discharge.

Manning equation: $v = (1.49/n)r_H^{2/3}S_o^{1/2}$

$n = 0.028$

r_H = hydraulic radius = S/L_p

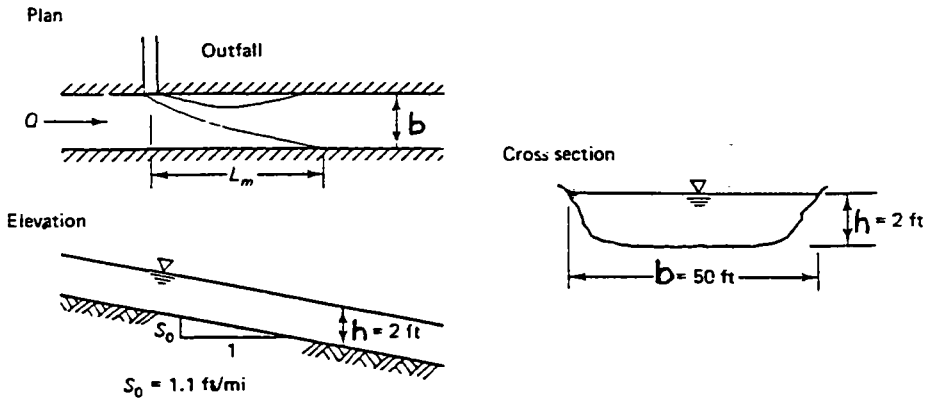
S_o = slope of the channel bed

For a midstream discharge: $L_m = 1.3vb^2/h$

For a side bank discharge: $L_m = 2.6vb^2/h$

1 mi = 5280 ft

(50 marks)



1. (a) *Bincangkan mengenai zat abadi dan zat bukan abadi dalam kualiti air di hilir suatu sumber titik.*

(50 markah)

(b) *Bincangkan model filem perdiaman, dan teori penusukan.*

(50 markah)

2. *Satu pembukaan besar (> 10 cm) dari suatu kapal menyebabkan satu cecair ketumpatan-tinggi yang takterlarutcampurkan tertumpah ke dalam satu kolam air aliran lambat yang dalam. Dengan bantuan keadaan tumpahan hipotetis, terangkan fenomenon pelarutan perolakan paksa.*

(100 markah)

3. *Propanol dioksidakan di dalam air oleh tindak balas enzim microbial menurut:* $C_3H_7OH + 4.5O_2 = 3CO_2 + 4H_2O$. *Oksigen datangnya daripada udara di atas permukaan air. Pengoksidaan propanol berlaku pada kadar malar. Kadar kehilangan propanol ialah* $(-r_A) = 3.28 \times 10^{-4}$ *mg/L.s. Hitungkan*

(a) *kadar tindak balas penggunahabisan oksigen (kmol/s) di dalam satu* m^3 *air di permukaan cecair;*

(b) *kadar fluks molar* CO_2 *(kmol/*m^2*.s) apabila ia menyahserap menerusi* m^2 *permukaan air.*
Berat atom bagi unsur: $C = 12$, $H = 1.008$, $O = 16$

(100 markah)

4. *Huraikan bagaimana koefisien-koefisien pemindahan jisim di dalam sekitar laut dapat diukur dengan menggunakan satu radas simulasi pertukaran gas di dalam makmal. Tegaskan pembolehubah-pembolehubah yang terlibat dan bincangkan beberapa keputusan grafik bagi koefisien pemindahan fasa cecair.*

(100 markah)

5. *Masa yang dikehendaki untuk satu arus memulih daripada keadaan hipotetis tanpa oksigen terlarut ke hatap akhir ketepuan tertentu memberikan penunjuk mengenai kelajuan pengudaraan semula.*

(a) *Hitungkan masa yang dikehendaki bagi satu arus yang tiada oksigen untuk mencapai 50% ketepuan. Ini merupakan penyerapan oksigen separuh-hayat,* $\Delta_{O2} = \Delta^{o}_{O2}/2$ *bagi arus ini. Carikan jarak di hilir dan kepekatan oksigen.*

(b) *Hitungkan masa diperlukan untuk mencapai 90% ketepuan. Carikan jarak dan kepekatan seperti soalan (a).*
Data arus: Halaju purata, $v_w = 0.22$ *m/s; kedalaman purata* $h = 1.9$ *m;* $D_{(O2)W} = 1.80 \times 10^{-5}$ cm^2/s *pada 20 °C; suhu air = 30 °C; koefisien suhu bagi sistem dalam julat suhu ialah* $\theta = 1.018$.

$$\rho_{(O2)W} = \rho^{*}_{(O2)W} - [\rho^{*}_{(O2)W} - \rho^{o}_{(O2)W}]exp[-k_{(O2)W}t/h]$$

$$L = tv_w$$

Pada $30^{o}C$, $\rho^{*}_{(O2)W} = 7.53$ *mg* O_2/L

$$k_{(O2)W}/h = [D_{(O2)W}v_w]^{1/2}/h^{3/2}$$

$$\Delta_{O2} = \rho^{*}_{(O2)W} - \rho_{(O2)W}$$

$$k_{T1} = k_{T2}\theta^{(T1-T2)}$$

(100 markah)

6. (a) *Anggarkan separuh-hayat bagi n-heksana di dalam satu tompok licin minyak pada 75 °F. Tekanan wap bagi n-heksana ialah 3.0 psia.*

$Log\ p_1^* = 1.25 \log K + 1.60 \quad p_1^*$ *in atm,* $1\ atm = 14.7\ lb_f/in^2$

$x_{1O} = x^o_{1O} e^{-Kt}$

(50 markah)

(b) *Untuk satu arus semulajadi jernih seperti ditunjukkan, anggarkan kadar aliran volumetrik dan jarak untuk pencampuran sempurna bagi discas tebing.*

Persamaan Manning: $v = (1.49/n) r_H^{2/3} S_o^{1/2}$

$n = 0.028$

r_H = *jejari hidraulik* = S/L_p

S_o = *kelerengan teping*

Bagi discas tengaharus: $L_m = 1.3vb^2/h$

Bagi discas tebing: $L_m = 2.6vb^2/h$

$1\ mi = 5280\ ft$

(50 markah)